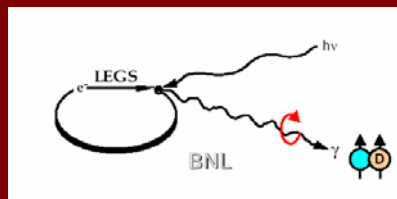




Brookhaven National Laboratory



UNIVERSITY of VIRGINIA

# TIME PROJECTION CHAMBER

for

## INTERMEDIATE ENERGY PHOTO-NUCLEAR STUDIES

Serdar Alptug KIZILGUL for the LEGS Spin Collaboration

LC-TPC R&D Meeting, October 18<sup>th</sup>, 2003

UC Berkeley, San Francisco, CA



University of Virginia

# LEGS Spin Collaboration

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# Summary

- Introduction
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- SASY
- TPC
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- GEM
- Conclusion

# Introduction

LEGS Spin Collaboration performs experiments on the **X5A** beam line of the National Synchrotron Light Source (NSLS) at the Brookhaven National Laboratory (BNL).

The **GOAL** of the LEGS Spin Collaboration is,

To determine fundamental properties of the proton and the neutron from measurements of the **spin-dependent reaction amplitudes**.

Particularly, we would like to determine the **forward spin polarizability** and **Gerasimov Drell-Hearn sum rule integrals** for both the proton and the neutron using the same target and the same detection system, so we need to measure the **helicity 1/2 and 3/2 photo-reaction cross sections** with target and photon-beam spins parallel and anti-parallel.

$$\gamma = \frac{1}{4\pi^2} \int_{\omega_0}^{\infty} \frac{\sigma_{1/2} - \sigma_{3/2}}{\omega^3} d\omega$$

Forward Spin Polarizability Sum Rule

$$-\frac{2\pi^2\alpha}{m^2} \kappa^2 = \int_{\omega_0}^{\infty} \frac{\sigma_{1/2} - \sigma_{3/2}}{\omega} d\omega$$

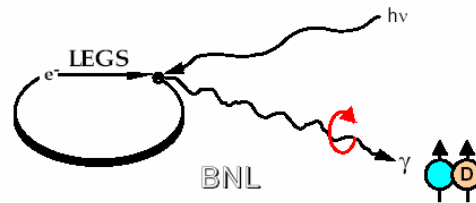
Gerasimov-Drell-Hearn Sum Rule

# Introduction

This experiment requires the development of a detector system which is capable of detecting and momentum analyzing in coincidence charged particles emitted over a wide angular range.

# LEGS

The Laser Electron Gamma-ray Source (LEGS) produces beams of tagged gamma-rays up to 470 MeV by backscattering laser light from 2.8 GeV electrons circulating a storage ring of the NSLS at BNL.

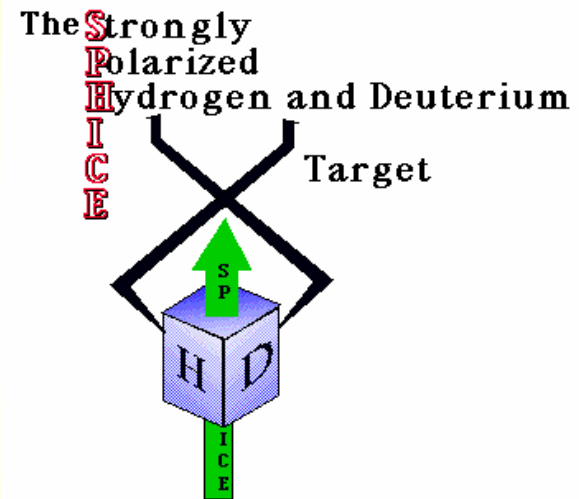


The chief characteristic which distinguishes the LEGS beam from other sources of gamma-rays is its **high degree of polarization**, typically greater than 90%.

# SPHICE

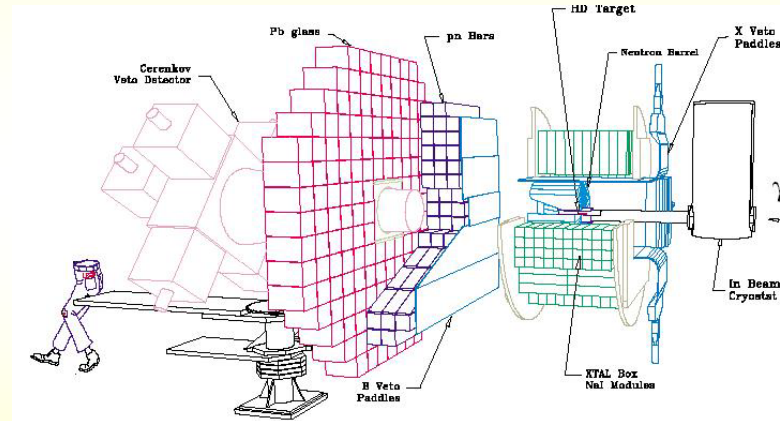
A Strongly Polarized Hydrogen and deuterium  
ICE Target, (SPHICE)

The combination of the LEGS polarized photon  
beams and SPHICE is uniquely suited to  
measurements of the helicity dependent cross  
sections that determine the forward  
polarizability and Gerasimov Drell-Hearn sum  
rule integrals



# SASY

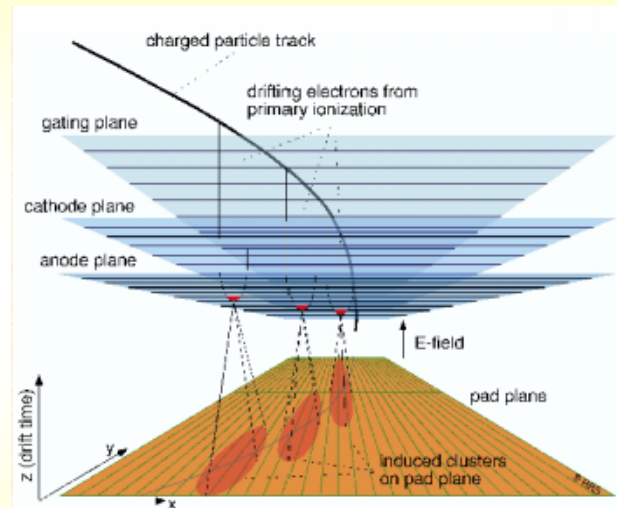
The Spin-ASYmmetry detector array, (SASY) is a large solid angle detector system which consists of a several subsystems of wire chambers, scintillators and Cerenkov detectors. The SPHICE target will be at the center of the detector.



The principal motivation for assembling this array are to measure the total reaction cross sections needed in the determination of the spin-dependent polarizability of a nucleon and GDH sum rule.

# Time Projection Chamber

The TPC is a large volume drift chamber with uniform parallel electric and magnetic fields.



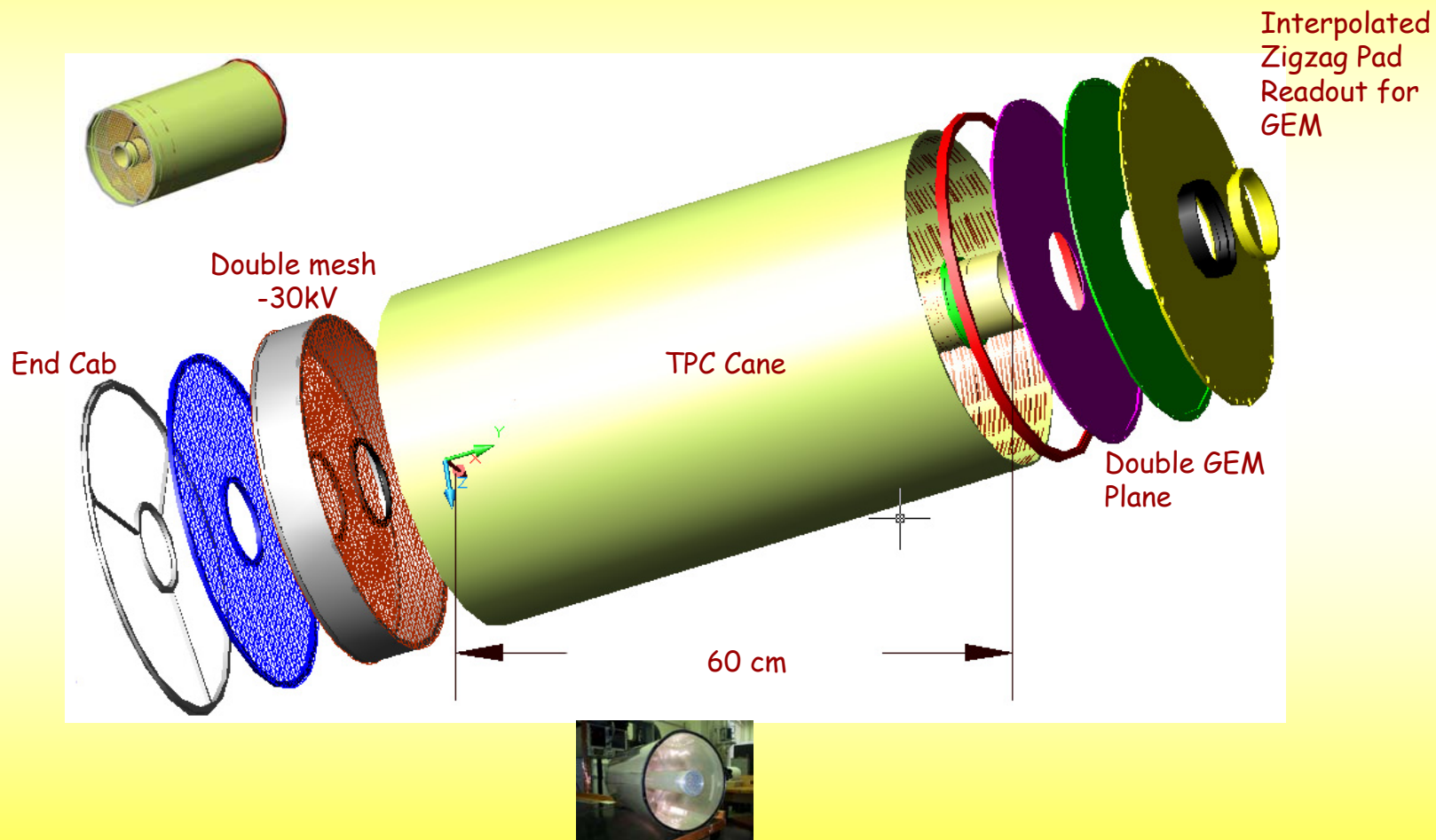
The TPC measures the spatial coordinates of the trajectory of a charged particle by detecting the ionization electrons produced by the charged particle in the gas of the chamber and by measuring their drift times and arrival positions on sensitive electrodes.

# LEGS TPC Specifications

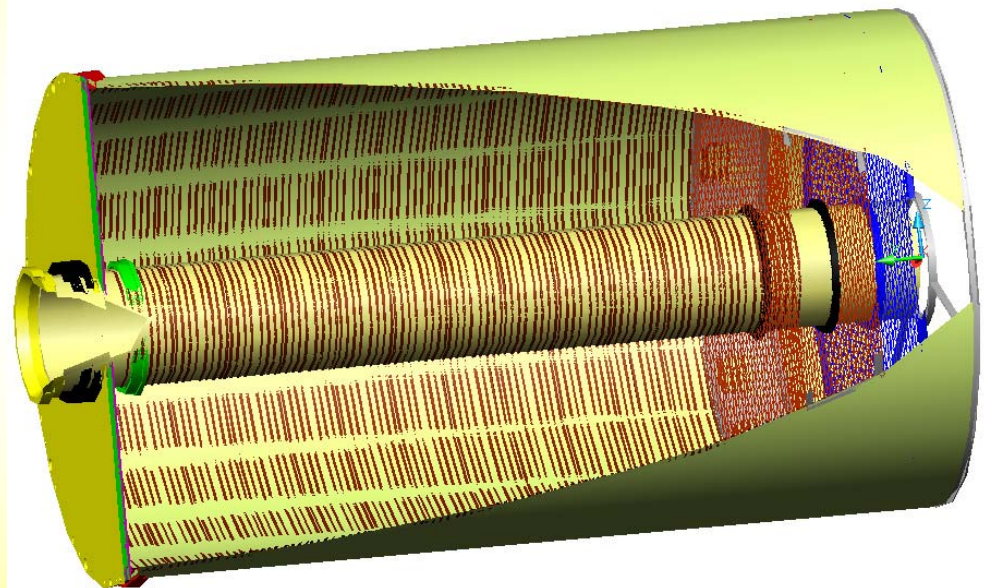
The key specifications are:

- \* Designed for low rate, low multiplicity environment: single sample per channel per trigger
- \* TPC Active Volume: Inner diameter  $\sim 9\text{cm}$ ; Outer diameter  $\sim 35\text{cm}$ ; Drift Length:  $50\text{cm}$
- \* Double GEM amplification, gas gain  $\leq 1000$
- \* Drift field  $\sim 600\text{V/cm}$  ( $-30\text{kV}$  high voltage), total drift time  $\sim 5\mu\text{s}$ .
- \* Interpolating zigzag anode pad plane,  $200\mu\text{m}$  position resolution for stiff tracks
- \* Readout channel count  $\sim 8000$
- \* Customized ASICs, 32 channels per chip,  $1\text{mW}$  per channel
- \* Electronic noise  $< 250\text{e}$ ,  $500\text{ns}$  peaking time, single peak time and amplitude measurement, timing resolution  $\sim 20\text{ns}$
- \* 8 sets of ADCs digitize the sparsified and serialized data streams, worst case event processing time  $< 0.5\text{ms}$

# LEGS TPC



# LEGS TPC



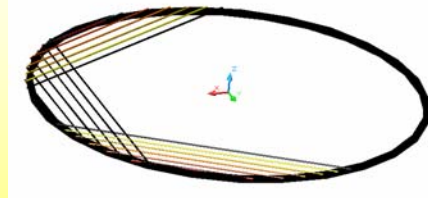
# High Voltage Mesh

Used 80 micrometer diameter copper kapton wire  
with 1 cm spacing

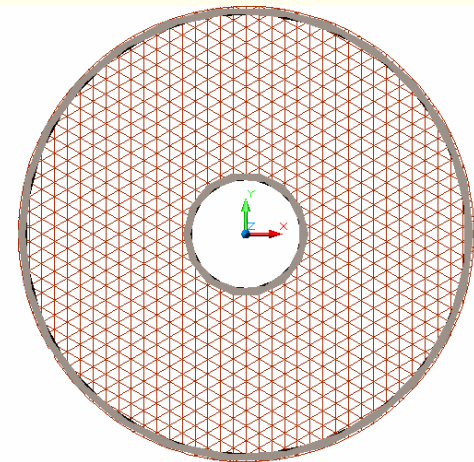
Wires constructed with 60 degree angle and  
construction sequence like below

To have

decrease tension on each wire,  
uniformly distributed Electric field over mesh surface  
high opening area percentage

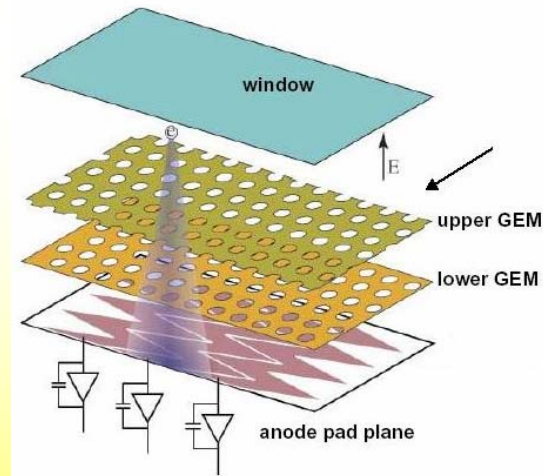


Mesh Construction Sequence



# GEM

The Gas Electron Multiplier (GEM) is a new particle detector technique. It uses a thin sheet of plastic coated with metal on both sides and chemically pierced by a regular array of holes a fraction of a millimeter across and apart. Applying a voltage across the GEM, the resulting high electric field in the holes makes an avalanche of ions and electrons pour through each. The electrons are collected by a suitable device.



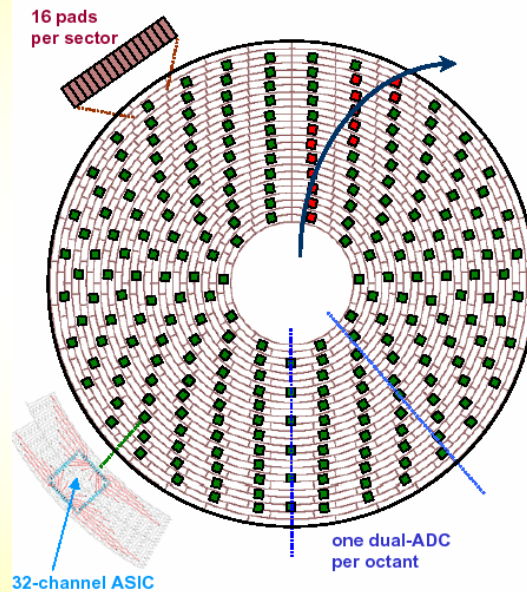
Interpolated zigzag pad readout for double GEM

# Conclusion

- Prototype expected to be ready by in three months,
- Construction of LEGS TPC will be completed by the end of 2004
- Running experiment planned to start early 2005

Thanks to LBNL to organize such unique symposium

## Front-End Electronics – Specifications



### Tracking Measurement

- Energy - triggered pad
- Energy - neighbor pads (centroid)
- Timing of triggered pad (z)

### Specifications

- ENC < 500 e<sup>-</sup> rms
- Timing < 20ns rms
- Preamplifier/shaper/BLH
- Adjustable gain  $\approx 17\text{-}32$  mV/fC
- Peak-detector
- Neighbor channel/chip enable
- Timing-detector (TAC)
- Channel masking
- Calibration
- On-chip buffers
- Token/flag readout